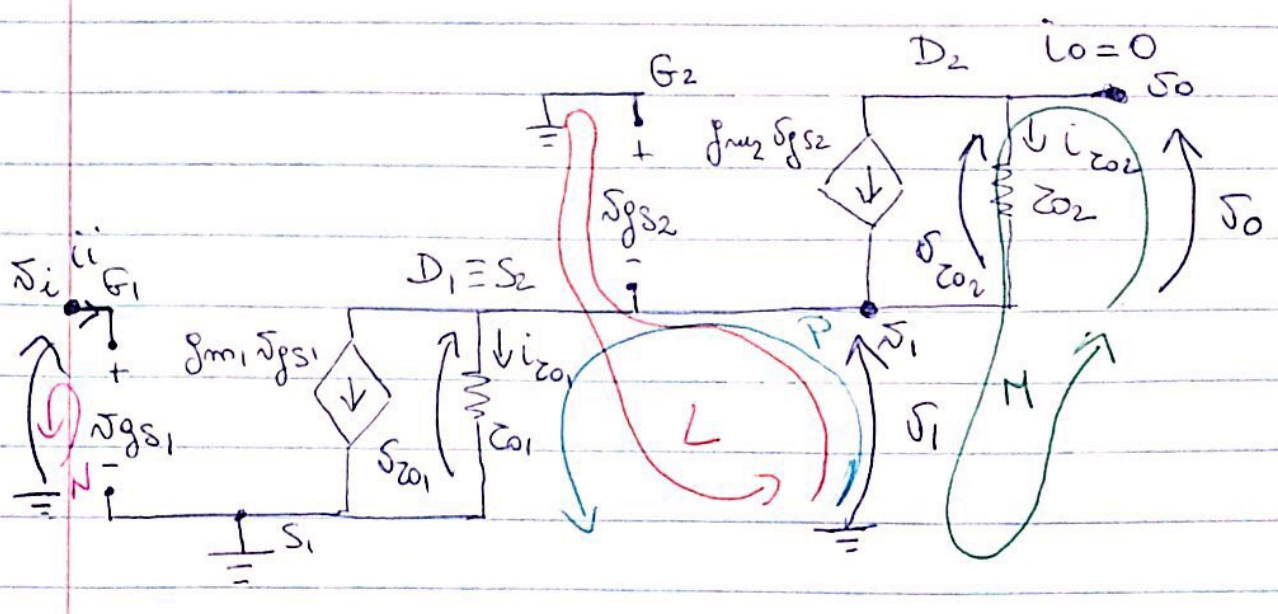
Cascode amplifier - Calculation of the gain and output and input resistance.




- $$A_{v_o} = \left.\frac{v_o}{v_i}\right|_{R_L' = \infty}$$

1) KCL @ $v_o$

$$g_{m_2} v_{gs_2} + i_{r_{o2}} = 0 \quad (1)$$

2) KVL @ L

$$v_1 + v_{gs2} = 0 \Rightarrow v_{gs2} = -v_1 \quad (2)$$

3) Using the Ohm's law for $v_{r_{o2}}$ and $i_{r_{o2}}$

$$i_{r_{o2}} = \frac{v_{r_{o2}}}{r_{o_2}} \quad (3)$$

4) KVL @ M

$$v_o - v_{r_{o_2}} - v_1 = 0 \Rightarrow v_{r_{o2}} = v_o - v_1 \quad (4)$$

5) By combining equations (1)-(4) we obtain

$$\frac{v_o - v_1}{r_{o2}} - g_{m2} v_1 = 0 \quad (5)$$

6) KCL @ node $v_1$

$$i_{ro1} + g_{m1} v_{gs1} = 0 \quad (6)$$

7) KVL @ N

$$v_{gs1} - v_i = 0 \Rightarrow v_{gs1} = v_i \quad (7)$$

8) Using the Ohm's law for $i_{ro1}$ and $v_{o1}$

$$i_{ro1} = \frac{v_{ro1}}{r_{o1}} \quad (8)$$

9) KVL @ P

$$v_1 - v_{ro1} = 0 \Rightarrow v_{ro1} = v_1 \quad (9)$$

10) By combining (6) to (9) we obtain

$$\frac{v_1}{r_{o1}} + g_{m1} v_i = 0 \quad (10)$$

11) From (5)

$$v_o - v_1 - g_{m2} v_1 r_{o2} = 0 \Rightarrow v_o = v_1 (1 + g_{m2} r_{o2}) \quad (11)$$

12) From (10)

$$v_1 = -g_{m1} r_{o1} v_i \quad (12)$$

13) By combining (11) and (12) we obtain

$$v_o = -g_{m1} r_{o1} (1 + g_{m2} r_{o2}) v_i \quad (13)$$

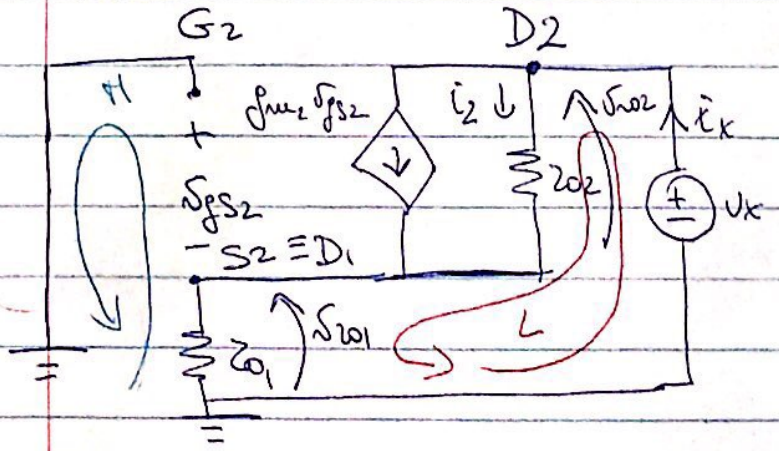
14) Thus the open-circuit voltage gain is

$$A_{vo} = \left.\frac{v_o}{v_i}\right|_{R_L' = \infty} = -g_{m1} r_{o1} (1 + g_{m2} r_{o2}) \simeq$$

$$\simeq -g_{m1} g_{m2} r_{o1} r_{o2}$$

- $R_{in} = \frac{v_i}{i_i} = \infty$

- Rout




$$R_{out} = \frac{v_x}{i_x}$$

1) KVL @ L

$$v_x - v_{ro2} - v_{ro1} = 0 \Rightarrow v_x = v_{ro2} + v_{ro1} \quad (1)$$

2) Ohm's law for $V_{Z2}$ and $i_2$ (current flowing in $Z_2$)

$V_{Z2} = i_2 Z_2$ (2)

3) Ohm's law for $V_{Z1}$ and $i_x$ (current flowing in $Z_1$)

$V_{Z1} = i_x Z_1$ (3)

4) KCL @ NODE D2

$i_2 - i_x + g_{m2} V_{gs2} \Rightarrow i_2 = i_x - g_m V_{gs2}$ (4)

5) KVL @ M

$V_{Z1} + V_{gs2} = 0 \Rightarrow V_{gs2} = -V_{Z1} \Rightarrow V_{gs2} = -i_x Z_1$ (5)

6) By combining (1) + (4) + (5) we obtain

$V_x = i_x (1 + g_{m2} Z_1) Z_2 + i_x Z_1$ (6)

7) Thus

$$R_{out} = \frac{V_x}{i_x} = Z_1 + Z_2 + g_{m2} Z_1 Z_2 \quad (7)$$